CLAIMS

The invention claimed is:

1. A device implantable in a body for controlling a flow of fluid in a duct, said duct comprising a wall having an interior surface defining an aperture and an exterior, said implantable device comprising an electroactive polymer transducer operable to selectively occlude said aperture by displacement of said exterior of said wall of said duct.

2. The device of claim 1 wherein said electroactive polymer transducer operable to selectively occlude said aperture by displacement of said exterior of said wall of said duct comprises:

   (a) an actuator having a dimension defined by a first surface and a second surface, said dimension being alterable by application of electrical energy; and

   (b) a case having a first portion supporting said actuator proximate to said exterior of said wall on a first side of said duct and a second portion disposed proximate to said exterior of said wall on a second side of said duct, said second side of said duct being substantially diametrically opposed to said first side, such that a change in said dimension of said actuator will cause said first surface of said actuator to displace a portion of said wall in a direction substantially normal to said second side of said duct.

3. The device of claim 2 further comprising a sensing transducer outputting a signal responsive to a force exerted by said actuator.

4. The device of claim 1 wherein said electroactive polymer transducer operable to selectively occlude said aperture by displacement of said exterior of said wall of said duct comprises:

(a) a first actuator having a dimension defined by a first surface and a second surface, said dimension alterable by application of electrical energy, said actuator restrained such that said first surface is proximate said exterior of said wall of said duct;

(b) a second actuator having a dimension defined by a first surface and a second surface and alterable by application of electrical energy, said second actuator restrained such that said first surface is proximate said exterior of said wall and substantially diametrically opposed to said first surface of said first actuator; and

(c) a case to restrain said first and said second actuators relative to said duct and to react a force caused by a change in said dimension of said first and said second actuators.

5. The device of claim 4 further comprising a sensing transducer outputting a signal responsive to a force exerted by said actuator.

6. The device of claim 2 wherein said electroactive polymer transducer operable to selectively occlude said aperture by displacement of said exterior of said wall comprises:

(a) a band having a length defined by a first end and a second end, said band being arranged to encircle an arc of a periphery of said exterior of said wall, said arc having a length less than a circumference of said wall; and

(b) an actuator having a dimension alterable by application of electrical energy, said actuator being connected to said first end and said second end of said band such that a change in said dimension will reduce said periphery of said exterior wall.

7. The device of claim 6 further comprising a sensing transducer outputting a signal responsive to a force exerted by said actuator.

8. A device implantable in a body for controlling a flow of fluid in a duct, said duct comprising a wall having an interior surface defining an aperture and an exterior, said implantable device comprising a piezoelectric transducer operable to selectively occlude said aperture by displacement of said exterior of said wall of said duct.

9. The device of claim 8 wherein said piezoelectric transducer operable to selectively occlude said aperture by displacement of said exterior of said wall of said duct comprises:

(a) an actuator having a dimension defined by a first surface and a second surface, said dimension being alterable by application of electrical energy; and

(b) a case having a first portion supporting said actuator proximate to said exterior of said wall on a first side of said duct and a second portion disposed proximate to said exterior surface of said wall on a second side of said duct, said second side of said duct being substantially diametrically opposed to said first side, such that a change in said dimension of said actuator will cause said first surface of said actuator to displace a

portion of said wall in a direction substantially normal to said second side of said duct.

10. The device of claim 9 further comprising a sensing transducer outputting a signal responsive to a force exerted by said actuator.

11. The device of claim 8 wherein said piezoelectric transducer operable to selectively occlude said aperture by displacement of said exterior of said wall of said duct comprises:

(a) a first actuator having a dimension defined by a first surface and a second surface, said dimension alterable by application of electrical energy, said actuator restrained such that said first surface is proximate said exterior of said wall of said duct;

(b) a second actuator having a dimension defined by a first surface and a second surface and alterable by application of electrical energy, said second actuator restrained such that said first surface is proximate said exterior of said wall and substantially diametrically opposed to said first surface of said first actuator; and

(c) a case to restrain said first and said second actuators relative to said duct and to react a force caused by a change in said dimension of said first and said second actuators.

12. The device of claim 11 further comprising a sensing transducer outputting a signal responsive to a force exerted by said actuator.

13. The device of claim 9 wherein said piezoelectric transducer operable to selectively occlude said aperture by displacement of said exterior of said wall comprises:

(a) a band having a length defined by a first end and a second end, said band being arranged to encircle an arc of a periphery of said exterior of said wall, said arc having a length less than a circumference of said wall; and

(b) an actuator having a dimension alterable by application of electrical energy, said actuator being connected to said first end and said second end of said band such that a change in said dimension will reduce said periphery of said exterior wall.

14. The device of claim 13 further comprising a sensing transducer outputting a signal responsive to a force exerted by said actuator.

15. A device implantable in a duct in a body for controlling a flow of fluid in said duct, said duct comprising a wall having an interior surface defining an aperture, said device comprising a transducer implantable in said aperture and operable to selectively occlude said aperture.

16. The device of claim 15 wherein said transducer implantable in said aperture comprises an electroactive polymer.

17. The device of claim 15 wherein said transducer implantable in said aperture comprises a piezoelectric material.

18. The device of claim 15 wherein said transducer implantable in said aperture comprises a polymer-metal composite.

19. The device of claim 15 wherein said transducer implantable in said aperture and operable to selectively occlude said aperture comprises a dilation element having a periphery responsive to electrical energy, said periphery being variable between a dilated periphery making substantial contact with said inner surface of said wall and a contracted periphery providing a space between said wall and said dilation element for fluid flow.

20. The device of claim 19 further comprising: an anchor connected to said dilation element to restrain said dilation element in said aperture.

21. The device of claim 19 wherein said transducer implantable in said aperture comprises an electroactive polymer.

22. The device of claim 19 wherein said transducer implantable in said aperture comprises a piezoelectric material.

23. The device of claim 15 wherein said transducer implantable in said aperture and operable to selectively occlude said aperture comprises:

(a) a valve seat restrained in said aperture, said valve seat comprising a channel for a flow of said fluid in said duct;

(b) a valve spool movable between a first position in contact with said valve seat to block said flow of said fluid in said channel and a second position not in contact with said valve seat to enable said flow; and

(c) an actuator responsive to electrical energy to move said valve spool from said first position to said second position.

24. The device of claim 23 wherein said actuator comprises an electroactive polymer.

25. The device of claim 23 wherein said actuator comprises a piezoelectric material.

26. The device of claim 23 wherein said transducer implantable in said aperture comprises a polymer-metal composite.

27. The device of claim 21 further comprising a stent engaging the interior of said aperture and connected to said valve seat.

28. The device of claim 21 wherein said valve spool movable between a first position in contact with said valve seat and a second position not in contact with said valve seat comprises an electroactive polymer dilation element having a dimension responsive to electrical energy, said dimension being variable between a dilated dimension substantially filling said channel and a contracted dimension smaller than a diameter of said channel.

29. A device implantable in a body for increasing a fluid pressure in a reservoir, said reservoir comprising a flexible wall having an exterior surface and an interior surface defining a volume, said device comprising an electroactive contractile transducer arranged to compress said exterior surface of said reservoir.

30. The device of claim 29 wherein said electroactive contractile transducer arranged to compress said exterior surface of said reservoir comprises a filament mesh including a filament comprising an electroactive polymer.

31. A device implantable in a body for increasing a fluid pressure in a reservoir, said reservoir comprising a flexible wall having an exterior surface and an interior surface defining a volume, said device comprising an electroactive contractile transducer having a first and a second end, said first and said

second ends being attached to said inner surface of said wall and defining a length of said transducer, said length being alterable by application of electrical energy to said contractile transducer.

32. A system for controlling a flow of fluid in a body duct including a wall having an interior surface defining an aperture for fluid flow and an exterior, said system comprising

(a) an electroactive polymer duct occluding transducer operable to selectively occlude said duct in response to a first signal;

(b) a program executable by a data processing device including a program instruction directing an output of said first signal; and

(c) a data processing device outputting said first signal to said electroactive polymer duct occluding transducer in response to said program instruction.

33. The system of claim 32 further comprising:

(a) a sensing transducer outputting a second signal to said data processing device, said second signal being responsive to one of a fluid pressure and a force exerted by said electroactive polymer duct occluding transducer; and

(b) another program instruction executable by said data processing device relating said second signal to said first signal.

34. The system of claim 32 further comprising

(a) a fluid pressure assist device for increasing a pressure of said fluid in a reservoir having a flow connection to said

duct, said fluid pressure assist device being response to third signal from said data processing device; and

(b) another program instruction executable by said data processing device relating said first signal and said third signal.

35. The system of claim 34 further comprising:

(a) a sensing transducer outputting a second signal to said data processing device, said second signal being responsive to one of a fluid pressure and a force exerted by said electroactive polymer duct occluding transducer; and

(b) an additional program instruction executable by said data processing device relating said second signal to at least one of said first signal and said third signal.

36. The system of claim 32 wherein said electroactive polymer duct occluding transducer operable to selectively occlude said duct in response to said first signal comprises an electroactive polymer actuator arranged proximate to said exterior of said duct and having a dimension responsive to said first signal to displace a portion of said exterior of said duct occluding said aperture.

37. The system of claim 32 wherein said electroactive polymer duct occluding transducer operable to selectively occlude said duct in response to said first signal comprises an electroactive polymer actuator arranged interiorly in said aperture and having a dimension responsive to said first signal to block said flow of fluid in said duct.

38. A system for controlling a flow of fluid in a body duct including a wall having an interior surface defining an aperture for fluid flow and an exterior, said system comprising

(a) a piezoelectric duct occluding transducer operable to selectively occlude said duct in response to a first signal;

(b) a program executable by a data processing device including a program instruction directing an output of said first signal; and

(c) a data processing device outputting said first signal to said piezoelectric duct occluding transducer in response to said program instruction.

39. The system of claim 38 further comprising:

(a) a sensing transducer outputting a second signal to said data processing device, said second signal being responsive to one of a fluid pressure and a force exerted by said piezoelectric duct occluding transducer; and

(b) another program instruction executable by said data processing device relating said second signal to said first signal.

40. The system of claim 38 further comprising

(a) a fluid pressure assist device for increasing a pressure of said fluid in a reservoir having a flow connection to said duct, said fluid pressure assist device being response to third signal from said data processing device; and

(b) another program instruction executable by said data processing device relating said first signal and said third signal.

41. The system of claim 40 further comprising:

(a) a sensing transducer outputting a second signal to said data processing device, said second signal being responsive to one of a fluid pressure and a force exerted by said piezoelectric duct occluding transducer; and

(b) an additional program instruction executable by said data processing device relating said second signal to at least one of said first signal and said third signal.

42. The system of claim 38 wherein said piezoelectric duct occluding transducer operable to selectively occlude said duct in response to said first signal comprises an piezoelectric actuator arranged proximate to said exterior of said duct and having a dimension responsive to said first signal to displace a portion of said exterior of said duct occluding said aperture.

43. The system of claim 38 wherein said piezoelectric duct occluding transducer operable to selectively occlude said duct in response to said first signal comprises a piezoelectric actuator arranged interiorly in said aperture and having a dimension responsive to said first signal to block said flow of fluid in said duct.

44. A device implantable in a body for controlling a flow of fluid in a duct, said duct comprising a wall having an interior surface defining an aperture and an exterior, said implantable device comprising a polymer-metal composite transducer operable to selectively occlude said aperture by displacement of said exterior of said wall of said duct.